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Beauty in the blink of an eye: The time course of aesthetic experiences

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Under normal circumstances, perception runs very fast and seemingly automatic. In just a few ms, we go from sensory features to perceiving objects. This fast time course does not only apply to general perceptual aspects but also to what we call higher-level judgements. Inspired by the study on 'very first impressions' by Bar, Neta, and Linz (2006, *Emotion*, **6**, 269) the current research examined the speed and time course of three aspects of the aesthetic experience, namely beauty, specialness, and impressiveness. Participants were presented with 54 reproductions of paintings that covered a wide variety of artistic styles and contents. Presentation times were 10, 50, 100 and 500 ms in Experiment 1 and 20, 30 and 40 ms in Experiment 2. Our results not only show that consistent aesthetic judgements can be formed based on very brief glances of information, but that this speed of aesthetic impression formation also differs between different aesthetic judgements. Apparently, impressiveness judgements require longer exposure times than impressions of beauty or specialness. The results provide important evidence for our understanding of the time course of aesthetic experiences.

From the moment we open our eyes, we clearly see the world around us and quickly extract information and meaning from it. Studies have found that when presented with real-world images, people are able to detect objects based on presentations as short as 50 ms and to recognize objects after only about 100 ms of presentation (see, e.g., Fei-Fei, Iyer, Koch, & Perona, 2007; Grill-Spector & Kanwisher, 2005). However, this fast processing comprises different stages. For example, Fei-Fei *et al.* (2007) found that before 40 ms, *sensory-related* features (light–dark) are dominant for people's perception of stimuli, while from around 50 ms of presentation, a shift to more object-related features occurs. Subjects are able to name very general object categories like manmade objects ('furniture', 'desk') and gradually get more detailed and accurate over time (Fei-Fei *et al.*, 2007). Such a coarse-to-fine development of percepts has been found in many psychophysical studies (for a review, see Hegdé, 2008) and is a core characteristic of the percept formation or *microgenesis* (Bachmann, 2000). What subjects perceive increases in detail the longer they see it, even if the image does not change. This happens on a very fast timescale (Fei-Fei *et al.*, 2007; Hegdé, 2008). A very vivid illustration that such speed and differentiated time course do not pertain only to general perceptual and identification aspects, such as colour or object category, but also to judgemental aspects

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of person perception, was presented by Bar, Neta, and Linz (2006; for further work on this topic, see, e.g., Todorov, Pakrashi, & Oosterhof, 2009 or Todorov & Porter, 2014).

In their study, Bar *et al.* (2006) examined whether people were able to form consistent 'first impressions' about others and how fast they could do this, that is, what minimal exposure time allowed them to come to consistent person judgements. Participants saw photographs of faces at 26, 39 and 1,700 ms, which they had to rate on an emotion-related feature (*threateningness*) and a personality-related feature (*intelligence*). Because such judgements – despite important influences of simple physical features for social trait impressions (Vernon, Sutherland, Young, & Hartley, 2014) – are inherently subjective, 'correctness' of judgements was determined as judgement consistency over time, by calculating the correlation between judgements with short exposure times (26 and 39 ms) on the one hand and long exposure time (1,700 ms) on the other hand. It appeared that people were consistent in judging the emotion-related feature, that is, *threateningness*, from whatever they could perceive within 39 ms – but this was not the case for the personality-related measure, *intelligence*. These results suggest that not only percepts per se develop in time – but also our judgements of these percepts (see also Bachmann & Vipper, 1983). To what extent these findings can be extended to other impressions and other aspects of impression formation remains to be investigated. The current study taps into this issue with a focus on the field of aesthetics: How much viewing time do people need to form aesthetic impressions, and to what extent does that differ between different aesthetic judgements?

Aesthetics has more and more become a 'hot topic' in psychological literature in the past few years (see, e.g., Augustin & Wagemans, 2012; Jacobsen, 2010; Leder & Nadal, 2014; Redies, 2015). The exact nature of the processes involved in attraction, rejection, etc., is still relatively unclear, although it is clear that aesthetic experiences involve a complex interplay of cognitive and affective processes assessed by different aesthetic judgements (Leder, Belke, Oeberst, & Augustin, 2004). Moreover, models of aesthetic experiences (Leder *et al.*, 2004; Leder & Nadal, 2014; for a comparable model regarding music, see Brattico, Bogert, & Jacobsen, 2013) clarify that aesthetics- and art-related perception are also subject to an underlying time course. Leder *et al.* (2004) define the aesthetic experience as a process to 'cognitively master [an] artwork' (p. 493), which is accompanied by continuously upgrading affective states and results in 'an (aesthetic) emotion'. (p. 493). The person's affective state can be assessed at any of these stages and may differ depending on the state of processing. Thus, the model conceives of aesthetic experiences as complex phenomena, in which gradual development and change are inherent.

Early evidence favouring this assumption came from Cupchik and Berlyne (1979). They explored how fast people could discriminate *collative properties* of paintings and whether these collative properties had an effect on perceived pleasingness. Collative properties refer to the relationship between elements within the stimulus and include the degree of ambiguity, complexity, and familiarity (Berlyne, 1971; Cupchik & Berlyne, 1979). The results of the Cupchik and Berlyne (1979) study showed that people are able to discriminate collative properties (and paintings varying on those properties) very quickly, with presentation times (PTs) of 50 ms being enough to gather the relevant visual information. According to the authors, this indicates that the initial stage of visual processing is holistic and is a stage of higher alertness and tension.

In 1983, Bachmann and Vipper replicated and extended the findings by Cupchik and Berlyne (1979). Using rating scales derived from Berlyne's collative scales (Berlyne, 1974), they found that people could not only differentiate art styles based on collative properties, but that this differentiation already seemed to be apparent starting from a presentation time of 1 ms only. It has to be taken into account that trials were unmasked, which makes interpretations in terms of exact timing difficult. Nevertheless, the results by Bachmann and Vipper (1983) suggest that people only need very brief glimpses of visual information to differentiate different kinds of art.

Locher, Krupinski, Mello-Thoms, and Nodine (2007) took a more general approach to the time course of art perception to find out in what order different aspects of artworks are perceived. Based on their subjects' free reports and eye movements, they propose that the change in pictorial properties of a percept (e.g., symmetry, complexity, structural features) might already reach a highly advanced stage after about 100 ms: Within 100 ms, people can extract enough information to form a significant holistic impression of the semantic meaning (i.e., gist) of paintings, including expressive aspects and 'meaningful' aesthetic judgements, as indicated by a significant correlation between *pleasingness* ratings at 100 ms and at unlimited PT. The observation that people can form a holistic impression after a single glance (100 ms; Locher *et al.*, 2007) is in line with the finding that people can describe a scene in superordinate categories at similar speed (after 107 ms of presentation, according to Fei-Fei *et al.*, 2007; 50 ms, Grill-Spector & Kanwisher, 2005). Extending this work to more specific properties of artworks, Augustin, Leder, Hutzler, and Carbon (2008) found that processing of content in art can already be traced after 10 ms glances and is already strongly developed after presentations of around 50 ms, whereas style processing emerges from about 50 ms of presentation and develops more slowly. Thus, content processing seems to be faster than style processing, but the latter is – nevertheless – impressively fast if one thinks of the complexity one would normally assume for style judgements.

The studies cited above – implicitly or explicitly – all work with a 'classical' microgenetic approach (see Bachmann, 2000) that systematically varies perceptual conditions and thus the informational basis at each processing stage. Others have examined temporal aspects of art perception and aesthetic phenomena via alternative methods, esp. EEG, to examine the duration of mental processes (e.g., Augustin, Defranceschi, Fuchs, Carbon, & Hutzler, 2011b; Jacobsen & Höfel, 2003). For example, Jacobsen and Höfel (2003) presented evidence that the brain seems to differentiate between beautiful and non-beautiful patterns in a time window of about 300 and 400 ms post-stimulus onset, as reflected in an early frontocentral phasic negativity specific to non-beautiful judgements.

The previous studies all illustrate that there is a time course in the perception of relational ('collative') properties of the percept of paintings (Bachmann & Vipper, 1983) as well as in the perception of style and content (Augustin *et al.*, 2008). It has also been shown that the percept and differences and/or changes in the percept influence perceived arousal and pleasure (Cupchik & Berlyne, 1979; Locher *et al.*, 2007). In addition, studies focusing on mental chronometry have rendered first estimations of the duration of processing underlying beauty judgements (Jacobsen & Höfel, 2003). Very little is yet known about the temporal unfolding of the aesthetic experience in terms of the development of its different facets. As discussed above, aesthetic experiences are supposed to be very complex in nature, comprising different kinds of aesthetic judgements and emotions at different stages of processing (Brattico *et al.*, 2013; Leder *et al.*, 2004), with beauty only being one – even though very important – facet of many (Augustin, Wagemans, & Carbon, 2012; Jacobsen, Buchta, Köhler, & Schröger, 2004; Knoop, Wagner, Jacobsen, & Menninghaus, 2016). To find out more about the temporal unfolding of different aesthetic judgements will thus be an additional step to shed further light on the processes involved in aesthetic experiences, which – as stated above – still remain rather poorly understood, in spite of a growing body of systematic research.

The current study adapted the logic followed by Bar *et al.* (2006) to the realm of art perception, in order to find out how quickly different aesthetic impressions can be formed, that is, how short the presentation time can be for people to come to different aesthetic judgements, and to what extent this time course of aesthetic impression formation differs between different aesthetic judgements. We also examined differences in response time (RT) between judgements as an indicator of judgement complexity. Our study follows a 'classical' microgenetic approach (e.g., Augustin *et al.*, 2008; Bachmann & Vipper, 1983): Viewing conditions are systematically varied in order to find out about the stages involved in the formation of aesthetic judgements.

Based on the literature and our previous studies, we focused on three aesthetic scales: *beauty*, *specialness,* and *impressiveness*.

In empirical studies, *beauty* has emerged as a core concept of aesthetic experiences. This could be shown not only in general (Jacobsen *et al.*, 2004), but also when comparing different visual object classes (Augustin *et al.*, 2012) as well as, very recently, in the field of literature (Knoop *et al.*, 2016). In his factor-analytic studies, Markovic (2010) found a factor 'aesthetic experience' that is dominated by aspects of *specialness*. In our view, this is not a contradiction: Cupchik and Gebotys (1988) identified pleasure and interest as two dimensions of aesthetic responses, with pleasure being more affectively and interest more cognitively based. In the Augustin *et al.* study (2012), terminology around the idea of 'being special' played a central role for visual art (besides beauty), and beauty, specialness, emotiveness, and impressiveness were important aesthetic factors in another study by the same authors (Augustin, Carbon, & Wagemans, 2011a). Our pilots for the current research project, however, showed that 'emotional' ('emotioneel' in Dutch) showed very little variance. This may be due to the fact that subjects in our study viewed reproductions of paintings on a computer screen (for details of method, see further) and that judgements of emotionality may be much more sensitive to circumstances than other aesthetic judgements. To avoid such biases in the results, we replaced this scale by *impressiveness*. 'Impressive' also appeared as an important aesthetic term, especially for landscapes and buildings, in the study by Augustin *et al.* (2012). The concept of impressiveness shows close relatedness to the idea of the sublime, which holds a special relationship with beauty and the aesthetic in philosophy (e.g., Burke, 1990; originally published in 1757; Kant, 1991; originally published in 1764; Schopenhauer, 1948, originally published in 1818). According to Burke (1990, originally published in 1757), the sublime and the beautiful constitute opposite poles, with the former being related to potentially dangerous or terrifying objects and the latter to pleasing, 'nice' objects and tension relief.

The current study aimed to uncover the time course of these three scales. Based on the literature, we chose presentation times of 10, 50, 100, and 500 ms in a first step and 20, 30, and 40 ms in a second step. According to Augustin *et al.* (2008), content processing starts with PTs of around 10 ms and is already strongly developed after 50 ms of presentation – the point where a shift from sensory-related to object-related processing seems to occur (Fei-Fei *et al.*, 2007) and where people start detecting objects (Fei-Fei *et al.*, 2007; Grill-Spector & Kanwisher, 2005). The same study by Augustin *et al.* (2008) suggests that style processing supposedly emerges around 50 ms of presentation. Another important time point in visual processing seems to lie around 100 ms until which subjects are able to perceive the global scene but not the details (Fei-Fei *et al.*, 2007). This also seems to be the point where subjects can form a holistic impression of a painting and can make consistent judgements about it (Locher *et al.*, 2007). As our pilot studies showed that there is already a strong development in aesthetic judgements between the 10 and 50 ms conditions, we decided to conduct a second experiment to scrutinize this time frame. In both experiments, unlimited presentation times served as the baseline. Following the logic presented by Bar *et al.* (2006) our main measure were the correlations between the judgements at each of the limited PTs (10, 20, 30, 40, 50, 100, and 500 ms) and at unlimited viewing time. These were regarded to indicate how far developed, that is, how consistent, a judgement is at different presentation durations. In sum, we conducted two experiments: a first with 10, 50, 100 and 500 ms PTs and an unlimited presentation baseline, and a second with PTs of 20, 30, 40 ms, and unlimited presentation baseline.

Method

Pre-study

The pre-study served to select diverse materials with a broad range in both style and content that allowed for a wide range of aesthetic impressions. Starting point was a list of 18 Western European and North American art styles, drawn together in collaboration with an art historian. The selection of art styles was made on the basis of commonness, as measured by their appearance in art books and museums. In addition, the styles were to represent a wide range of styles, with as little overlap as possible between them. For each art style, we chose between three and 15 paintings of diverse style and content, and, for the sake of diversity, by at least three different painters. This procedure resulted in a basic set of 225 paintings. Reproductions were downloaded from the DVD 25,000 Meisterwerke [masterworks] (Directmedia Publishing: zeno.org, 2007), www.artstor.com (Artstor), from sites of museums listed on www.artcyclopedia.com (Artcyclopedia.com) and from Wikipedia. Only high-quality reproductions of paintings were accepted. All pictures were resized to 140,000 square pixels at 72dpi.

Twelve university students participated (10 women; M(age) = 20.38 years, SD (age) = 1.80 years). None of them had received any formal training in art or art history beyond regular school education.

Participants judged the paintings in two blocks, during each of which all paintings were presented in random order at unlimited presentation time. In the first block, participants were asked to rate the strength of their aesthetic impression on a scale from 1 to 7, with 1 = *a very weak impression* and 7 = *a very strong impression* – positive or negative. This formulation was used to be sure people rated the strength and not the valence of their impression. In the second block, participants were asked whether they had seen the paintings before they participated ('yes'/'no').

Paintings known by 10% of participants or more were removed from the analyses. To make it easier to compare ratings of the *strength of aesthetic impression* (M = 3.460, SD = 1.601) between paintings, z-scores were calculated per painting. On the basis of these z-scores, three paintings were selected per art style, one that made a weak impression ($z \approx -1$), one that made an intermediate impression ($z \approx 0$), and one that made a strong impression ($z \approx 1$).[1] This resulted in a selection of 54 paintings for the main study (see Appendix A).

[1] *If more reproductions met the z-score criteria, two additional criteria were used: (1) a broad range in style and content and (2) three different painters within every style.*

EXPERIMENT 1

Participants

Twelve paid volunteers participated in this experiment. Our sample consisted of four male and eight female participants aged 18–57 (M = 29.8 years, SD = 13.0 years). Three participants were working, and the others were students. None of them had received any formal training in art or art history beyond regular school education. All had normal or corrected-to-normal vision.

Stimuli

The stimuli consisted of 54 reproductions of paintings of 18 different art styles from the 15th century to the 1960s (see Appendix A), selected in a pre-study, as described above. Figure 1 shows black-and-white versions of two artworks used for the study.

These stimuli were also used to construct coloured noise masks via an algorithm that has been proven useful to yield efficient masks (Torfs, Panis, Barthlema, & Wagemans, 2012). The algorithm divided our stimuli into squares of 5 $\times$ 5 pixels, removed all completely white squares from this pool, and randomly assembled the squares to form new combinations of 561 $\times$ 497 pixels. Eighteen of such combinations were created to serve as masks.

Procedure

The experiment was programmed and controlled by the experimental software E-Prime (Psychology Software Tools Inc.) and run on a Dell Precision T5400 PC. The screen had a resolution of 1,280 $\times$ 1,024 and a 100-Hz refresh rate. The stimuli sizes ranged from 10.37 to 18.77 cm in width and from 9.24 to 16.79 cm in height. With a viewing distance of about 60 cm, this resulted in visual angles ranging from 9.06° to 16.10° in the horizontal and from 8.09° to 14.48° in the vertical axis. All instructions were given in Dutch.

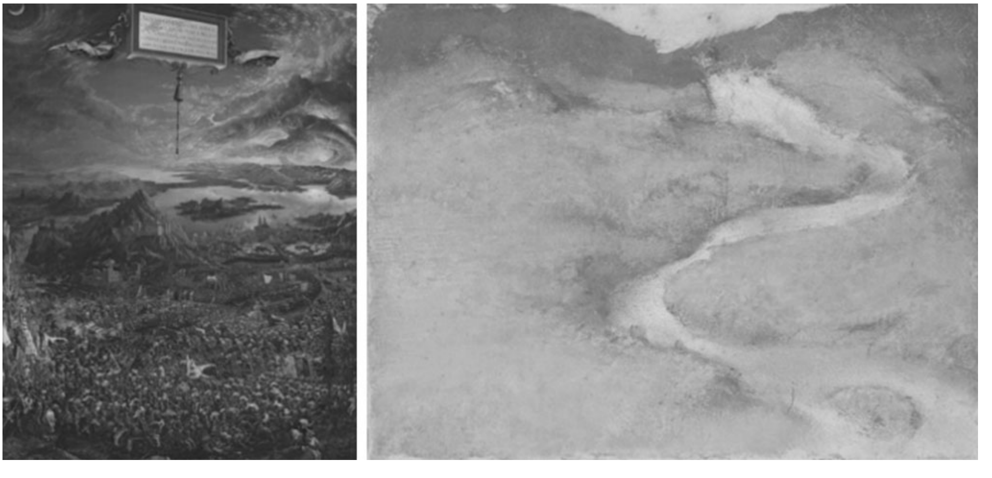

Figure 1. Two black-and-white versions of artworks used for the study (left to right): 'The Alexander battle (Battle of Issus)' by Albrecht Altdorfer, 1529. © Bayerische Staatsgemäldesammlungen – Alte Pinakothek Munich. 'Pathway in a field', by Edgar Degas, 1890. © Yale University Art Gallery.

In a first block, participants were presented with ten practice trials that were identical to the experimental trials except for the stimuli (see Appendix B). The experiment was divided into two blocks. In the first block, stimuli were presented at 10, 50, 100, and 500 ms. The stimuli and stimulus–PT combinations were randomly intermingled. In the second block, the same stimuli were presented at unlimited PT. Each trial consisted of a 250-ms presentation of a fixation cross, followed by a stimulus at one of the four PTs and a 250-ms presentation of a coloured noise mask (Figure 2a). Then, ratings on three 7-point Likert type of scales were asked for all the scales at the same time, *beautiful* ('mooi' in Dutch), *special* ('speciaal' in Dutch), and *impressive* ('indrukwekkend' in Dutch) (1 = 'not at all' to 7 = 'very much'). The order of the scales was balanced over participants using a Latin square logic. In order not to confuse participants, the order of scales was identical within participants in both blocks.

At the end of the experiment, participants were asked whether they had seen the paintings before as well as some questions concerning their experience with art, namely whether they studied or had taken courses in art history, how many times they visited a museum, and how many art books they possessed. Participants were also asked whether they used any strategies in their ratings. This information allowed us to get an idea about potential artefacts in the results.

In total, participants gave 54 (paintings) × 5 (presentation times) × 3 (scales) = 810 ratings.

EXPERIMENT 2

Experiment 2 had the same logic as Experiment 1, but shorter PTs were used, which led to minor changes in the experimental procedure.

Participants

Twelve people (seven female and five male) participated in this experiment – none of them had participated in Experiment 1 or the pre-study. The participants' age ranged between 21 and 55 years (M = 31 years, SD = 13 years). Three participants studied psychology, two studied law, and one studied applied economical sciences. Five participants were graduated and had a job, and one was unemployed. All participants

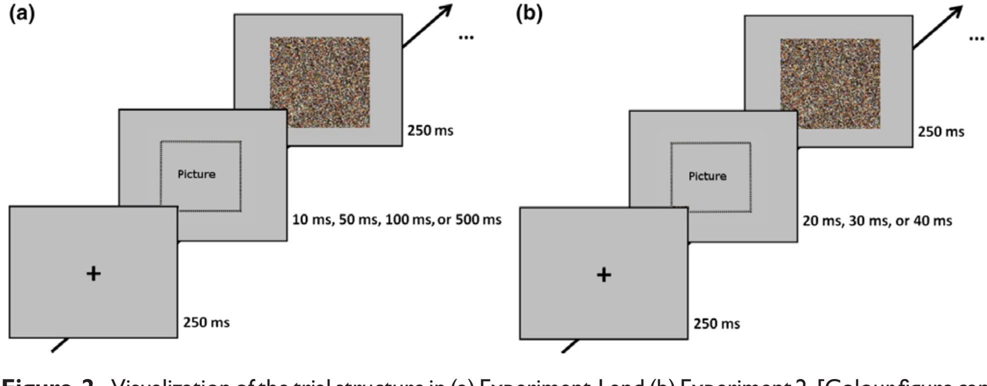

Figure 2. Visualization of the trial structure in (a) Experiment 1 and (b) Experiment 2. [Colour figure can be viewed at wileyonlinelibrary.com]

were volunteers. None of the participants had received any formal training in art of art history. The participants had normal or corrected-to-normal vision.

Stimuli

Stimuli and the coloured noise masks were the same as in Experiment 1.

Procedure

The stimuli were presented at 20, 30, and 40 ms and unlimited PT. Because of the shortness of the PTs, we assumed it might be too difficult for participants to give all three judgements in a row (assuming that quickly flashed pictures also leave only short-lived visual memories). For this reason, it was decided to include only one scale per block for the short PTs. The order of blocks was completely balanced across participants. A fourth block was included for unlimited presentation time. The fourth block was also divided into three sub-blocks, one per scale. For the sake of clarity, the order of sub-blocks was the same within participants as the order of the first three blocks. To familiarize participants with the experiment, there were two practice blocks, each with a different scale. Apart from this, the practice trials were identical to those of blocks 1 and 2 in Experiment 1 (Figure 2b) for limited and unlimited PT, respectively.

In total, participants gave 54 (paintings) $\times$ 4 (PTs) $\times$ 3 (scales) = 648 ratings.

At the end of Experiment 2, we asked the same questions on familiarity and art knowledge as described for Experiment 1.

Results

General descriptive results and data preparation

Before analysing the results, the data were inspected for possible outliers. On the basis of the RT histograms, we defined a cut-off value of 10s. This caused 0.6% of the data for Experiment 1 and 0.5% for Experiment 2 to be excluded from further analysis.

The remaining data were used to answer the following questions: What is the minimal presentation time that people need to extract the relevant information for different aesthetic judgements? Do different aesthetic judgements develop differently over viewing time? And how fast or slow are people in making these different judgements?

In order to directly compare differences between the scales, the type of judgement (*Scale*) was included as a variable in the ANOVAs rather than considering the scales as different dependent variables. In addition, it can be assumed that the scales used are aspects of a broader aesthetic experience and are thus not fully separate measures.

In all our repeated-measures ANOVAs, *p*-values were obtained using Greenhouse–Geisser $\hat{\varepsilon}$ corrected degrees of freedom (*df*).

Figure 3a,b plots the means of the ratings per scale per PT, with 1 *SD* error bars.

Onset and development of aesthetic judgements

To see how the aesthetic judgements develop in time, judgements at limited presentation times were correlated with the corresponding judgements at unlimited PT. We assume that the judgement at unlimited PT is based on a comparatively advanced aesthetic impression (assuming that a ‘full’ aesthetic impression can perhaps never be assessed, at

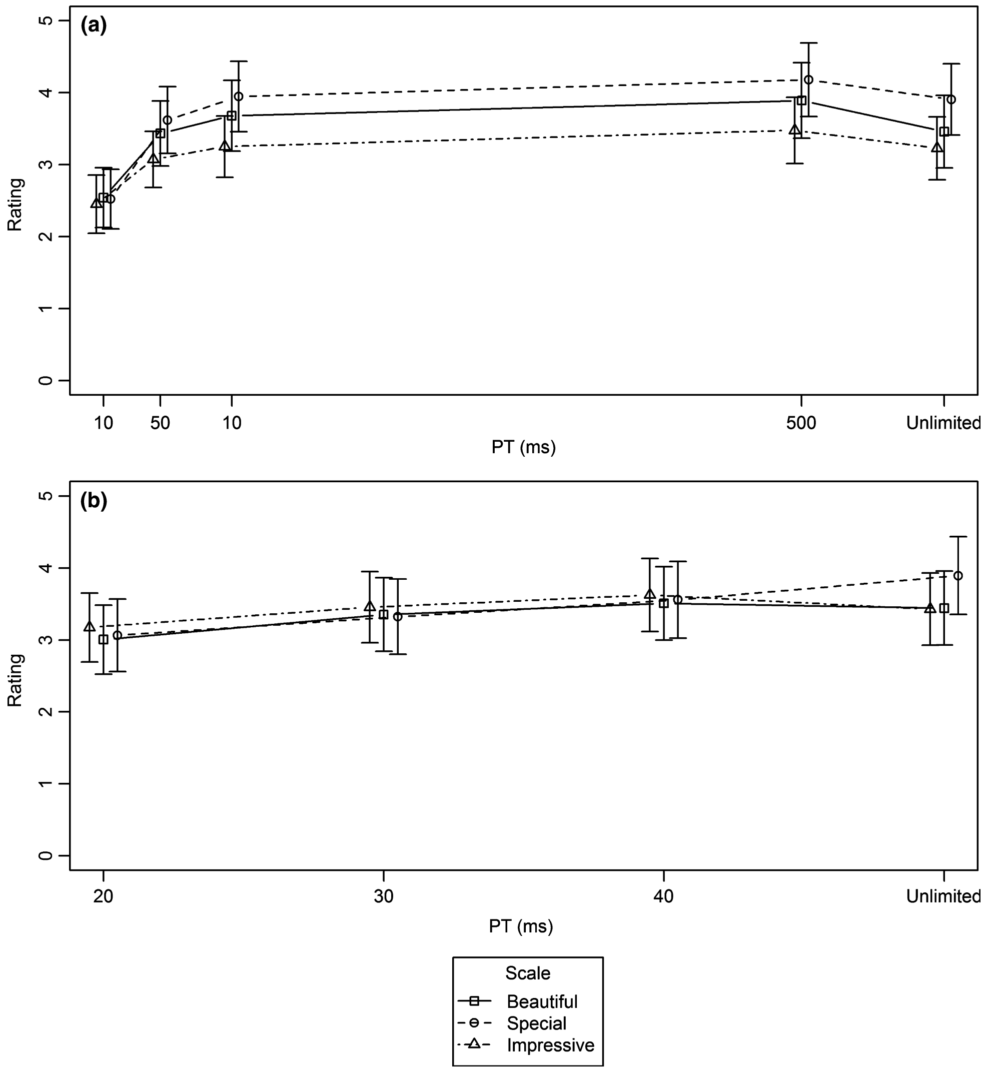

Figure 3. Means and one standard deviation error bars of *Judgement* (*y*-axis) per *Presentation Time* (*PT*; *x*-axis) for (a) Experiment 1 and (b) Experiment 2, separated by *Scale*.

least not under experimental circumstances). The correlation between judgements at limited and at unlimited PT then reflects how far the judgement is already developed after a certain amount of viewing time (see also Introduction).

To increase the power of the correlation analysis, we averaged over subjects and calculated the Pearson correlations over stimuli ($n = 54$).

EXPERIMENT 1

None of the correlations was significant at 10 ms (ps $> .05$). Correlations for all the scales were significant for presentation times of 50 ms and higher (ps $< .05$). Figure 4a shows the correlations plotted against time.

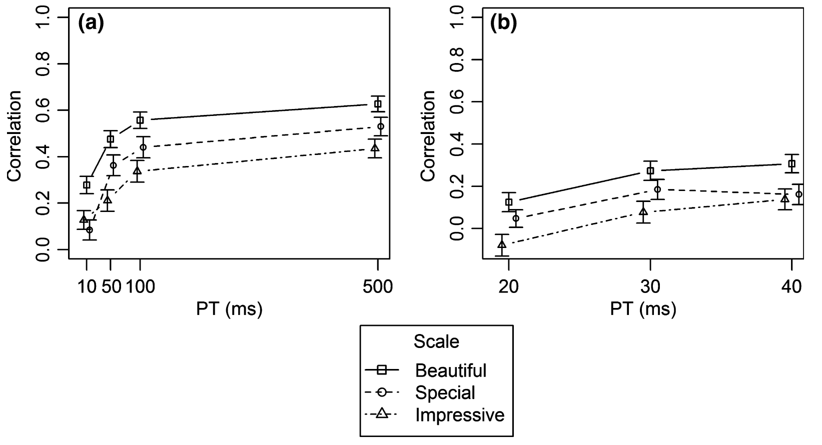

Figure 4. Correlations between short PT and unlimited time (*y*-axis) per *PT* (*x*-axis) and one standard deviation error bars divided by *Scale* for (a) Experiment 1 and (b) Experiment 2.

To test for time-related trends, we performed a 3 (*Scale*) × 4 (*PT*) repeated-measures ANOVA and simple main effects analyses. In this case, Fisher's *z* corrected correlations were calculated per stimulus over persons (*Fz(r)*), and the ANOVA was conducted over stimuli to increase its power.

The ANOVA showed a main effect for *PT*, $F(2.581, 136.781) = 32.017$, $p \leq .0001$, $\eta^2 = .377$, a main effect for *Scale*, $F(1.940, 102.827) = 29.597$, $p \leq .0001$, $\eta^2 = .358$, and no interaction, $F(4.840, 256.518) = 1.816$, $p = .112$. More specifically, the simple main effects analysis (for details, see Table C1 in Appendix C) yielded significant differences between all PTs (*p*s ≤ .045), with higher PTs having higher correlations. These results show that in the time window between 10 and 100 ms of presentation, there is a general development of rating values over time. Furthermore, one can observe a significant difference between the scales (*p*s ≤ .006). *Impressive* has lower correlations than *special*, which again has lower correlations than *beautiful*. From this, it can be concluded that overall *beautiful* develops faster than *special,* which appears to develop faster than *impressive*. However, these time course differences between scales appear to be general offset differences, not slope differences, as the *Scale–PT* interaction is not significant.

EXPERIMENT 2

Experiment 2 examined the development of aesthetic impressions in more detail within the window of viewing times between 10 and 50 ms, at 20, 30, and 40 ms. Here, the correlations with unlimited PT (performed over stimuli) for *beautiful* and *special* were not significant at 20 ms (*p*s > .05). Correlations were significant from 30 ms on (*p*s < .05). The correlations for the scale *impressive* were not significant at any PT. Figure 4b presents a plot of the correlations.

To statistically compare the development of our three aesthetic judgements between 20 and 40 ms of presentation, we conducted a 3 (*Scale*) × 3(*PT*) repeated-measures ANOVA with the *Fz(r)* of the judgements as dependent measure and simple main effects analyses on the *Fz(r)*. As in Experiment 1, the ANOVA was conducted over stimuli, with Fisher's *z* corrected correlations calculated per stimulus over persons.

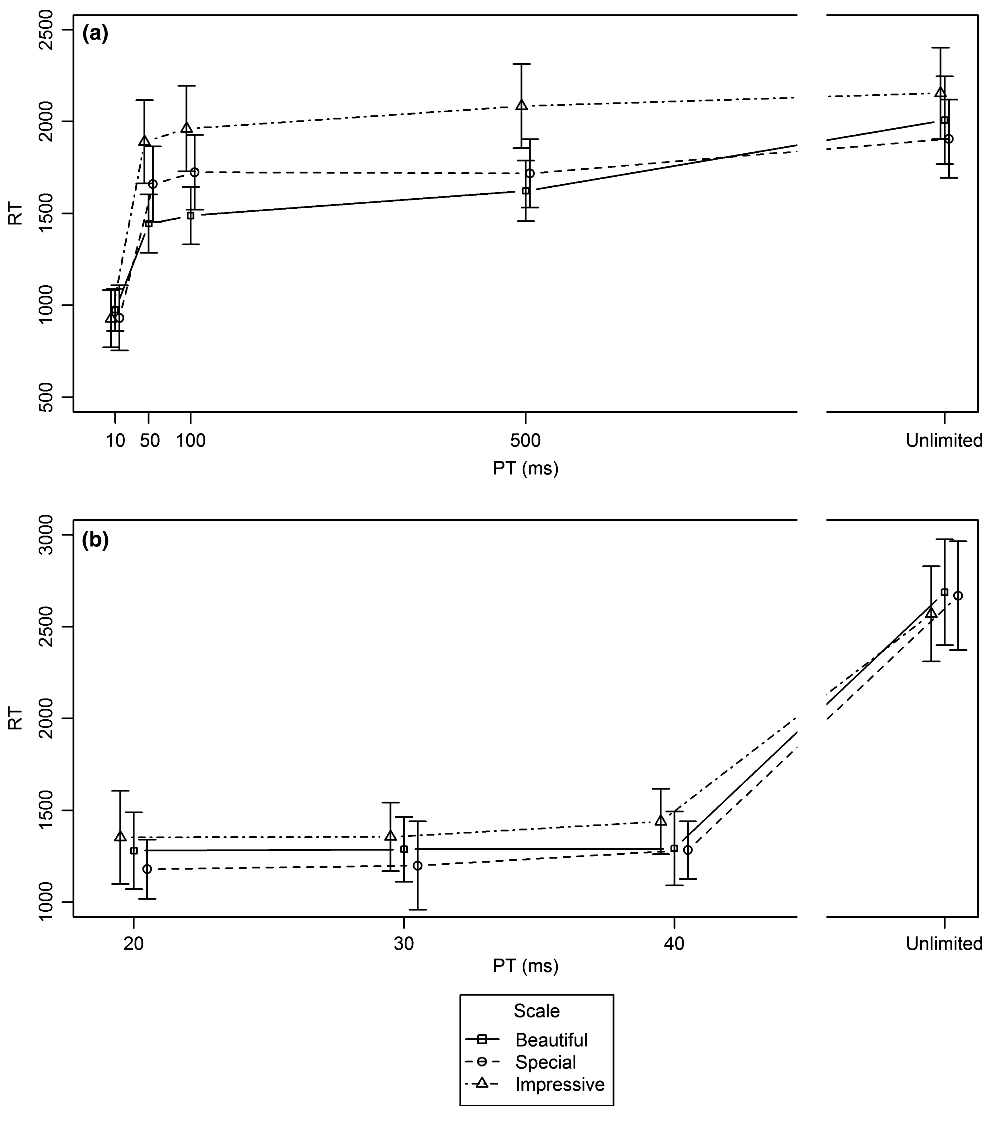

Figure 5. *Response Times* (RT; *y*-axis) per *PT* (*x*-axis) and one standard deviation error bars divided by *Scale* for (a) Experiment 1 and (b) Experiment 2.

The ANOVA yielded a significant main effect of *PT*, $F(1.891, 100.198) = 23.067$, $p \leq .0001$, $\eta^2 = .303$. We also observed a significant main effect of *Scale*, $F(1.855, 98.318) = 8.447$, $p = .001$, $\eta^2 = .137$, but no interaction, $F(3.642, 193.033) = .758$, $p = .542$. Simple main effects analyses (for details, see Table C2 in Appendix C) showed significant differences between 20 and 30 ms, and between 20 and 40 ms (ps $\leq .0001$). The correlations at 30 and 40 ms were both higher than at 20 ms, showing a strong development between the 10 and 50 ms conditions. However, the difference between 30 and 40 ms is not significant ($p = .417$). Correlations for *impressive* differed significantly from both *beautiful* and *special* (ps $\leq .0001$), with correlations for *impressive* being lower than for the other two judgements. The difference between *beautiful* and *special* also reached significance (p = .041). The correlation for *beautiful* was higher than for *special*. This suggests that between 10 and 50 ms of presentation *impressive* develops more slowly than both *beautiful* and *special*, while *special* seems to lie somewhere in between *impressive* and *beautiful* in terms of speed.

Speed of judgement

Differences in speed of judgements between the scales were analysed to find further hints regarding the complexity or difficulty in the different judgements (see, e.g., Dodonov & Dodonova, 2012). As participants were asked to answer as fast as possible, it is assumed that the difficulty in judgement and the PT (amount of visual information) might lead to variation in response times (*RTs*).

The means of RTs ranged from 920 to 2,154 ms for Experiment 1, with standard deviations between 195 ms and 470 ms (Figure 5a). In Experiment 2, the means of the RTs lay between 1,180 and 2,669 ms and standard deviations ranged from 320 to 564 ms (Figure 5b).

EXPERIMENT 1

The 3 (*Scale*) × 4 (*PT*) repeated-measures ANOVA over stimuli with *RT* as dependent measure yielded a significant main effect for *PT*, $F(3.462, 1833.506) = 155.395$, $p \leq .0001$, $\eta^2 = .746$, and a significant main effect for *Scale*, $F(1.805, 95.670) = 30.243$, $p \leq .0001$, $\eta^2 = .363$. Also a significant interaction, $F(6.614, 350.530) = 8.187$, $p \leq .0001$, $\eta^2 = .134$, was found. Simple main effects analyses (for details, see Table D1 in Appendix D) showed that all differences in RT between PTs are significant ($ps \leq .012$) except between 50 and 100 ms and between 100 and 500 ms. RT increases with longer PT. There is a significant difference between the scales *impressive* and *beautiful* and between the scales *impressive* and *special* ($p \leq .0001$). *Impressive* has longer RTs than the scales *beautiful* and *special*. These differences are significant from PTs of 50 ms on ($ps \leq .003$). However, the difference between *impressive* and *beautiful* fails to reach significance at unlimited PT. The difference in RT between *beautiful* and *special* is also significant at 50 ms (p = .002) and at 100 ms (p = .003) with *special* having longer RTs.

First of all, we observed longer RTs at longer PTs. This probably reflects a self-paced responding that is in synch with shorter or longer PTs. However, the non-significant difference in RT from 100 ms on can reflect a ceiling of time needed to process the stimuli for their aesthetic value.

In addition, it seems that from 50 ms on *impressive* ratings need a longer time than ratings for *beautiful* and *special*, with the difference disappearing at unlimited PT. This may potentially indicate that *impressive* is more complex and/or rational/cognitive than *beautiful* and *special*, requiring more reflection.

EXPERIMENT 2

The 3 (*Scale*) × 4 (*PT*) repeated-measures ANOVA over stimuli with *RT* as dependent variable showed a significant main effect of *PT*, $F(2.768, 146.680) = 344.940$, $p \leq .0001$, $\eta^2 = .867$, no main effect of *Scale*, $F(1.933, 102.464) = 2.849$, $p = .064$, and no significant interaction, $F(5.206, 275.904) = 1.813$, $p = .107$. The simple main effects analyses (for details, see Table D2 in Appendix D) yield only a significant difference between the short PT and unlimited PT (ps $\leq$ 0001). Possibly, a 20-ms interval is not long enough to observe significant differences in processing length.

Potential effects of repeated exposure

Apart from our main questions, we checked for possible methodological effects in Experiment 2. Does repeated presentation of the paintings have an effect on the judgement? For that, the judgements were grouped according to the block the judgement was given in. Pearson correlations between the judgements at limited time and unlimited PT were calculated per block.

A 3 (*Block*) $\times$ 3 (*PT*) repeated-measures ANOVA on *Fz(r)* showed no significant effect of block and thus no reason to worry about possible effects of the blockwise rating method used in Experiment 2 (for ANOVA results, see Appendix E).

Discussion

The current study investigated the time course of aesthetic judgements, with a focus on three impressions that have been shown to be important for experiences of visual art (Augustin *et al.*, 2012): *beautiful*, *special,* and *impressive*. We were interested in two questions: What is the minimal presentation time on the basis of which people are able to form stable aesthetic judgements? And to what extent do the time courses of the three judgements differ – regarding both required viewing time and response times?

First of all, our results illustrate that people are extremely fast at forming aesthetic impressions. In many cases, a presentation of about 30 ms seems enough to extract the information that is relevant to come to a meaningful aesthetic judgement – not more time than is needed to extract the information pertaining to a face's threateningness (Bar *et al.*, 2006). Such extreme speed is in line with similar results from the aesthetics literature (e.g., Bachmann & Vipper, 1983; Cupchik & Berlyne, 1979). For example, Cupchik and Berlyne (1979) showed that participants differentiate paintings on the basis of the so-called collative properties after no more than 50 ms of presentation. Augustin *et al.* (2008) report first effects of content and style on similarity ratings of paintings after presentation times of 10 and 50 ms, respectively. Such results suggest that the extraction of information for 'basic' aesthetic processing does not necessarily require more time than for other perceptual tasks – even though aesthetic encounters undoubtedly have a special role for many people and aesthetic experiences stand out from other experiences in real life (see also Allesch, 2006). Correlations with unlimited PT yet do increase over time, as reflected in a main effect of PT in both experiments. This can be explained by reduced uncertainty of the percept (Cupchik & Berlyne, 1979). Still, only a glimpse of an artwork seems to be necessary to form an aesthetic judgement that is at least meaningful.

How fast aesthetic impression formation actually is yet seems to depend on the kind of judgement asked for: Whereas we find significant correlations with unlimited time from 30 ms of presentation on for *beautiful* and *special*, correlations for *impressive* only become significant for PTs of 50 ms and longer. ANOVAs in both Experiment 1 and Experiment 2 yield a significant main effect of judgement: Correlations with unlimited time for *impressive* are overall lower than for the other two judgements, with *special* lying in between *beautiful* and *impressive*. Thus, beauty seems to be the fastest aesthetic impression of the three, impressiveness the slowest. Differences in PT required for a meaningful judgement may, in turn, also imply that people need different kinds of visual information in order to form the three judgements, because a specific kind of information needed for a specific judgement can take a different amount of time in order to become represented in the perceptual system.

A similar picture is yielded by the inspection of response times, even though only in Experiment 1 (from 50 ms on) and with a slightly less clear pattern: Participants not only need shorter PTs to come to meaningful judgements of beauty and specialness than for impressiveness; response times are significantly faster too. There is no general response time difference between *beautiful* and *special*. The difference between beauty and impressiveness vanishes at unlimited time. Still, if we assume a direct relation between response time and processing time or task complexity (Dodonov & Dodonova, 2012), impressiveness needs longest processing and may be the most complex or difficult of the three judgements examined, despite potential confounds with motor execution times (see, e.g., Augustin *et al.*, 2011b).

Taken together, it looks as if people only need very little time to extract the most important information for judgements of beauty and specialness. Possibly, low-level sensory visual information, which according to Fei-Fei *et al.* (2007) dominates perception up to approximately 40 ms, may already be sufficient in this case. People can also detect and categorize based on what they perceive within 30 ms (Grill-Spector & Kanwisher, 2005) – but they cannot consciously or explicitly name what they saw (Fei-Fei *et al.*, 2007). This supposedly changes after about 50 ms of presentation: According to Fei-Fei *et al.* (2007), people then utter first descriptions/rough classifications of the objects they see. Similarly, Augustin *et al.* (2008) found first effects of style on judgements from 50 ms of presentation onwards, and Cupchik and Berlyne (1979) report the same time window for extraction of collative properties of paintings (Cupchik & Berlyne, 1979). Thus, explicit content classification, stylistic aspects, and collative properties are all among the 'candidate' information that may be of particular relevance for judgements of impressiveness. Which of these kinds of information is most relevant is an important question for further research. Moreover, this may differ between different kinds of stimulus materials. Roye, Höfel, and Jacobsen (2008) even reported temporal differences in the processing of facial beauty depending on the gender of the face. One potential explanation offered by the authors is that people use less cues to evaluate male beauty than female beauty. As for artworks, a relevant aspect to investigate in this respect is a potential difference between abstract and representational artworks. It may be reasonable to assume that content aspects and/or semantics are of particular importance for the development of aesthetic judgements. As we only had 11 fully abstract works in our stimulus sample, we are unable to provide a reliable analysis with our data, but the style of paintings in general and abstractness in particular is a factor that requires investigation in future research.

What do the current results imply for our understanding of art perception? As already mentioned above, it is beyond question that in order to experience an artwork in all its flavour one needs time, freedom, an adequate setting (e.g., museum), and, possibly, mindset (Leder *et al.*, 2004; Wagemans, 2011). In a real-life museum, setting viewing times will probably always exceed 10, 50, and also 500 ms (for a study on viewing times in the museum, see Smith & Smith, 2001). Nevertheless, the results of the current study reveal that people only need brief glimpses to form aesthetic judgements that – at least according to what one can measure in the laboratory – are already meaningful. Actually, the basics of aesthetic judgements already seem to be laid from about 30 ms on.

In their 2012 study on word usage and underlying concepts in visual aesthetics, Augustin *et al.* (2012) found that people are extremely differentiated in their aesthetic word usage, especially with a view to different object classes. *Beautiful* is the universal aesthetic term (see also Jacobsen *et al.*, 2004), while *special* is mostly relevant for visual art and clothing and *impressive* for visual art, landscapes, and buildings. Thus, different object classes seem to 'trigger' different kinds of aesthetic impressions, which, in turn, gives a hint at the nature of the different underlying aesthetic experiences. The current research now shows that people are not only differentiated in their aesthetic judgements, but that these judgements also differ in their general time course – even within object class. For visual art, beauty is fastest, impressiveness is slowest, and specialness seems to lie in between the two. This adds further important evidence regarding the processes involved in aesthetic experiences and may also help to further develop current models of aesthetic experience (e.g., Leder *et al.*, 2004).

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References

Allesch, C. (2006). *Einführung in die psychologische Ästhetik [Introduction to psychological aesthetics]*. Wien, Austria: Uni-Taschernbücher, Wiener Universitäts Verlag.

Artcyclopedia.com. *Art cyclopedia: The fine art search engine* [web database]. Calgary, Canada: Specifica, Inc. Retrieved from http://www.artcyclopedia.com/

Artstor. *Artstor digital library [database]*. New York, NY: Author. Retrieved from http://www.artstor.org/

Augustin, M. D., Carbon, C. C., & Wagemans, J. (2011a, August). Measuring aesthetic impressions of visual art (Poster). Presented at the 34th European Conference on Visual Perception (ECVP), Toulouse, France.

Augustin, M. D., Defranceschi, B., Fuchs, H. K., Carbon, C. C., & Hutzler, F. (2011b). The neural time course of art perception: An ERP study on the processing of style versus content in art. *Neuropsychologia*, *49*, 2071–2081. https://doi.org/10.1016/j.neuropsychologia.2011.03.038

Augustin, M. D., Leder, H., Hutzler, F., & Carbon, C. C. (2008). Style follows content: On the microgenesis of art perception. *Acta Psychologica*, *128*, 127–138. https://doi.org/10.1016/j.actpsy.2007.11.006

Augustin, M. D., & Wagemans, J. (2012). Empirical aesthetics, the beautiful challenge: An introduction to the special issue on Art & Perception. *I-Perception*, *3*, 455–458. https://doi.org/10.1068/i0541aap

Augustin, M. D., Wagemans, J., & Carbon, C.-C. (2012). All is beautiful? Generality vs. specificity of word usage in visual aesthetics. *Acta Psychologica*, *139*, 187–201. https://doi.org/10.1016/j.actpsy.2011.10.004

Bachmann, T. (2000). *Microgenetic approach to the conscious mind*. Amsterdam, The Netherlands: John Benjamins Publishing Company.

Bachmann, T., & Vipper, K. (1983). Perceptual rating of paintings from different artistic styles as a function of semantic differential scales and exposure time. *Archiv Für Psychologie [Archive for Psychology]*, *135*, 149–161.

Bar, M., Neta, M., & Linz, H. (2006). Very first impressions. *Emotion*, *6*, 269–278. https://doi.org/10.1037/1528-3542.6.2.269

Berlyne, D. E. (1971). *Aesthetics and psychobiology*. New York, NY: Appleton-Century-Crofts.

Berlyne, D. E. (1974). *Studies on the new experimental aesthetics. Steps toward an objective psychology of aesthetic appreciation*. New York, NY: Wiley.

Brattico, E., Bogert, B., & Jacobsen, T. (2013). Toward a neural chronometry for the aesthetic experience of music. *Frontiers in Psychology*, *4*, 1–21. https://doi.org/10.3389/fpsyg.2013.00206

Burke, E. (1990). *A philosophical inquiry into the origin of our ideas of the sublime and beautiful* (Vol. XXIX). Oxford, UK: Oxford University Press. (original work published 1757)

Cupchik, G. C., & Berlyne, D. E. (1979). The perception of collative properties in visual stimuli. *Scandinavian Journal of Psychology*, *20*, 93–104. https://doi.org/10.1111/j.1467-9450.1979.tb00688.x

Cupchik, G. C., & Gebotys, R. (1988). The experience of time, pleasure, and interest during aesthetic episodes. *Empirical Studies of the Arts*, *6*, 1–12. https://doi.org/10.2190/5yn3-j3p8-fwhy-udb3

Directmedia Publishing: zeno.org. (2007). *25000 Meisterwerke [25 000 masterpieces] [DVD-ROM]*. Berlin, Germany: Directmedia Publishing.

Dodonov, Y. S., & Dodonova, Y. A. (2012). Response time analysis in cognitive tasks with increasing difficulty. *Intelligence*, *40*, 379–394. https://doi.org/10.1016/j.intell.2012.07.002

Fei-Fei, L., Iyer, A., Koch, C., & Perona, P. (2007). What do we perceive in a glance of a real-world scene? *Journal of Vision*, *7*(1), 1–10. https://doi.org/10.1167/7.1.10

Grill-Spector, K., & Kanwisher, N. (2005). Visual recognition: As soon as you know it is there, you know what it is. *Psychological Science*, *16*, 152–160. https://doi.org/10.1111/j.0956-7976.2005.00796.x

Hegdé, J. (2008). Time course of visual perception: Coarse-to-fine processing and beyond. *Progress in Neurobiology*, *84*, 405–439. https://doi.org/10.1016/j.pneurobio.2007.09.001

Jacobsen, T. (2010). Beauty and the brain: Culture, history and individual differences in aesthetic appreciation. *Journal of Anatomy*, *216*, 184–191. https://doi.org/10.1111/j.1469-7580.2009.01164.x

Jacobsen, T., Buchta, K., Köhler, M., & Schröger, E. (2004). The primacy of beauty in judging the aesthetics of objects. *Psychological Reports*, *94*, 1253–1260. https://doi.org/10.2466/pr0.94.3c.1253-1260

Jacobsen, T., & Höfel, L. (2003). Descriptive and evaluative judgment processes: Behavioral and electrophysiological indices of processing symmetry and aesthetics. *Cognitive, Affective, & Behavioral Neuroscience*, *3*, 289–299. https://doi.org/10.3758/cabn.3.4.289

Kant, I. (1991). *Beobachtungen über das Gefühl des Schönen und Erhabenen [Observations on the feeling of the beautifull and sublime]*. Erlangen, Germany: Fischer. (original work published 1764)

Knoop, C. A., Wagner, V., Jacobsen, T., & Menninghaus, W. (2016). Mapping the aesthetic space of literature "from below". *Poetics*, *56*, 35–49. https://doi.org/10.1016/j.poetic.2016.02.001

Leder, H., Belke, B., Oeberst, A., & Augustin, M. D. (2004). A model of aesthetic appreciation and aesthetic judgments. *British Journal of Psychology*, *95*, 489–508. https://doi.org/10.1348/0007126042369811

Leder, H., & Nadal, M. (2014). Ten years of a model of aesthetic appreciation and aesthetic judgments: The aesthetic episode – Developments and challenges in empirical aesthetics. *British Journal of Psychology*, *105*, 443–464. https://doi.org/10.1111/bjop.12084

Locher, P., Krupinski, E. A., Mello-Thoms, C., & Nodine, C. F. (2007). Visual interest in pictorial art during an aesthetic experience. *Spatial Vision*, *21*, 55–77. https://doi.org/10.1163/156856807782753868

Markovic, S. (2010). Aesthetic experience and the emotional content of paintings. *Psihologija*, *43*, 47–64. https://doi.org/10.2298/psi1001047m

Psychology Software Tools Inc. (n.d.). E-Prime 2.0 [Computer software].

Redies, C. (2015). Combining universal beauty and cultural context in a unifying model of visual aesthetic experience. *Frontiers in Human Neuroscience*, *9*, 218. https://doi.org/10.3389/fnhum.2015.00218

Roye, A., Höfel, L., & Jacobsen, T. (2008). Aesthetics of faces. *Journal of Psychophysiology*, *22*, 41–57. https://doi.org/10.1027/0269-8803.22.1.41

Schopenhauer, A. (1948). *Die Welt als Wille und Vorstellung [The world as will and representation]* (Vol. 2 book 3). Zürich, Germany: Classen. (original work published 1818)

Smith, J. K., & Smith, L. F. (2001). Spending time on art. *Empirical Studies of the Arts*, *19*, 229–236. https://doi.org/10.2190/5mqm-59jh-x21r-jn5j

Todorov, A., Pakrashi, M., & Oosterhof, N. N. (2009). Evaluating faces on trustworthiness after minimal time exposure. *Social Cognition*, *27*, 813–833. https://doi.org/10.1521/soco.2009.27.6.813

Todorov, A., & Porter, J. M. (2014). Misleading first impressions different for different facial images of the same person. *Psychological Science*, *25*, 1404–1417. https://doi.org/10.1177/0956797614532474

Torfs, K., Panis, S., Barthlema, A., & Wagemans, J. (2012, September). Temporal dynamics of candidate interpretations during object recognition. Presented at the 35th European Conference on Visual Perception (ECVP), Alghero, Italy.

Vernon, R. J., Sutherland, C. A., Young, A. W., & Hartley, T. (2014). Modeling first impressions from highly variable facial images. *Proceedings of the National Academy of Sciences of the United States of America*, *111*, E3353–E3361. https://doi.org/10.1073/pnas.1409860111

Wagemans, J. (2011). Towards a new kind of experimental psycho-aesthetics? Reflections on the Parallellepipeda project. *I-Perception*, *2*, 648–678. https://doi.org/10.1068/i0464aap

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Appendix A: List of experimental stimuli per art style

Art style	Painting	Painter	Year
Renaissance	The Alexander battle (Battle of Issus)	Altdorfer, Albrecht	1529
	Portrait of an old Woman	Giorgione	Ca. 1500–1510
	Santa Maria Novella	Ghirlandaio, Domenico	1485–1490
Mannerism	The hell	Beccafumi, Domenico	1526–1530
	The stone cutter	van Hemessen, Jan Sanders	Ca. 1514–1550
	Sheppard	Bloemaert, Abraham	1628
Baroque	Genre scene with Masks	Bonito, Guiseppe	Mid-18th century
	The stoning of Saint Stephan	Elsheimer, Adam	Ca. 1600
	Still life with fish	van Beyeren, Abraham Hendriksz	1655–1666
Classicism/ Neoclassicism	Cossack girl at Mazeppa's body	Chassériau, Théodore	1851

Continued

Appendix A (*Continued*)

Art style	Painting	Painter	Year
	Oedipus	Gérôme, Jean-Léon	1867–1868
	Self-portrait	Feuerbach, Anselm	1854
Rococo	Blind man's bluff	Troost, Cornelis	2nd quarter 18th century
	The Strode family	Hogarth, William	1738
	Head of a woman	Boucher, François	Ca. 1750
Romantism	Honeymoon	von Schwind, Moritz	1867
	Daybreak	von Schwind, Moritz	1858
	Lake Tahoe	Bierstadt, Albert	1868
Realism	Arrival of the sorcerers at the wedding	Maximow, Wassilij Maximowitsch	1875
	Village politics	Leibl, Wilhelm Maria Hubertus	1877
	Steel press (modern day Cyclopes)	von Menzel, Adolf Friedrich Erdmann	1872–1875
Impressionism	Pathway in a field	Degas, Edgar	1890
	Comtesse Adèle de Toulouse-Lautrec, at Breakfast	Toulouse-Lautrec, Henri de	1881–1883
	Glowing of the sun	Claus, Emile	1905
Art Nouveau	Dance	Mucha, Alfons	1898
	Three Woman and Three Wolves	Grasset, Eugène	1900
	The Autumn Bride	Levy-Dhurmer, Lucien	1896
Expressionism	The World-cow	Marc, Franz	1913
	The Windbride	Kokoschka, Oskar	1913
	Carnival in Arcueil	Feininger, Lyonel	1911
Cubism	Denstedt	Feininger, Lyonel	1917
	Femme Assise	Metzinger, Jean	1919
	Still-life with scull	Kubista, Bohumil	1912
Abstract expressionism	After Khorkum	Gorky, Arshile	1940–1942
	Untitled	Gorky, Arshile	1943
	Arabesque	Hamilton Bush, Jack	1975
Surrealism	Fascination	Brauner, Victor	1939
	How to make a rainbow	Cornell, Joseph	ca. 1963, 1965
	Dutch Interior II	Mirò, Joàn	?
Action painting	Minter	Poons, Larry	1975
	White squares	Krasner, Lee	ca. 1948
	Number 7	Pollock, Jackson	1951
Pop Art	The continuous monument	Natalini, Adolfo; di Francia, Cristiano Toraldo; Superstudio; Magris, Alassandro; Frassinelli, Gian Piero	1969
	Alka Seltzer	Lichtenstein, Roy	1966
	Painted Bronze	Johns, Jasper	1960
Photorealism/ Hyperrealism	Water	Gertsch, Franz	?

Continued

Appendix A (*Continued*)

Art style	Painting	Painter	Year
	Trace Chain II	Don Eddy	1995
	Waverly Place	Estes, Richard	1980
Fauvism	The Piano Lesson	Matisse, Henri	1916
	London Bridge	Derain, André	1906
	Woman at the Window	Friesz, Othon	1919
Concrete Art	Thirty vertical systematic colour series in a yellow rhombic form	Lohse, Richard Paul	1970
	Tekers-MC	Vasarely, Victor	1981
	Two cells with conduit	Halley, Peter	1987

Appendix B: List of practice stimuli per art style

Art style	Painting	Painter	Year
Renaissance	Annunciation	Albertinelli, Mariotto	1508
Mannerism	Farmers carnival	Bol, Hans	2nd half 16^{N} century
Baroque	An angel opens the grave of Christ	Cuyp, Benjamin Gerritsz	1640
Classicism/ Neoclassicism	Aeneas reports Dido about the downfall of Troy	Guérin, Pierre-Narcisse	1815
Rococo	The chemist	Longhi, Pietro	Ca. 1752
Romantism	Canal Grande in Venice	Turner, Joseph Mallord William	1835
Realism	Fox in the snow	Courbet, Gustave	1860
Impressionism	Road to Port-Marly	Pisarro, Camille	1860–1867
Art Nouveau	Love	Klimt, Gustav	1895
Expressionism	The Vampire	Munch, Edvard	1895
Cubism	Couple	Pascin, Jules	1915
Abstract expressionism	Carnival	Gorky, Arshile	1943
Surrealism	The great Sirens	Delvaux, Paul	1947
Action Painting/abstract impressionism	Cotherman	Poons, Larry	1981
Pop Art	Landscape 3	Lichtenstein, Roy	1967
Photorealism/Hyperrealism	Luciano Castelli I	Gertsch, Franz	1971
Fauvism	Interior with seated Figure	Matisse, Henri	1920–1921
Concrete Art	Variation 13	Bill, Max	1938

Appendix C: Results simple main effects analysis on correlations

Table C1. Results of simple main effects analysis on Fisher's *Z* corrected correlations for Experiment 1

Comparison	*M*	*SE*	95% *CI*[a]
PT			
10–50 ms	−.242**	.052	[−.347; −.137]
10–100 ms	−.388**	.062	[−.512; −.263]
10–500 ms	−.511**	.064	[−,640; −.382]
50–100 ms	−.145*	.050	[−.246; −.045]
50–500 ms	−.268**	.053	[−.374; −.162]
100–500 ms	−.123*	.045	[−.213; −.032]
Scale			
Impressive–beautiful	−.285**	.040	[−.365; −.206]
Impressive–special	−.110*	.038	[−.187; −.033]
Beautiful–special	.175**	.034	[−.107;.243]

Note. *M* = mean difference; *SE* = standard error; 95% *CI* = 95% confidence interval.
*$p < .01$; **$p < .001$.
[a]*CI* Least significance difference corrected.

Table C2. Results of simple main effects analysis on Fisher's *Z* corrected correlations for Experiment 2

Comparison	*M*	*SE*	95% *CI*[a]
PT			
20–30 ms	−.167**	.030	[−.227; −.108]
20–40 ms	−.190**	.034	[−.258; −.122]
30–40 ms	−.023	.032	[−.078;.033]
Scale			
Impressive–beautiful	−.217**	.056	[−.329; −.105]
Impressive–special	−.097*	.045	[−.188; −.007]
Beautiful–special	.120*	.057	[.005;.234]

Note. *M* = mean difference; *SE* = standard error; 95% *CI* = 95% confidence interval.
*$p < .05$; **$p < .001$.
[a]*CI* Least significance difference corrected.

Appendix D: Results simple main effects analyses on response times

Table D1. Results of simple main effects analysis on response times for Experiment 1

Comparison	*M*	*SE*	95% *CI*[a]
PT			
10–50 ms	−719.987***	44.602	[−809.448; −630.525]
10–100 ms	−786.289***	38.768	[−864.047; −708.531]
10–500 ms	−865.577***	37.759	[−945.323; −785.831]
10 ms–Unlimited	−1086,207***	45.005	[−1176.476; −995.938]
50–100 ms	−66.302	41.375	[−149.290;16.686]
50–500 ms	−145.591*	56.050	[−258.012; −33.169]
50 ms–Unlimited	−366.221***	25.186	[−470.892; −216.549]
100–500 ms	−79.289	44.800	[−169.147;10.570]
100 ms–Unlimited	−299.918***	50.586	[−401.380; −198.457]
500 ms–Unlimited	−220.630***	49.476	[−319.866; −121.394]
Scale			
Impressive–beautiful	287.103***	32.631	[223.660;350.546]
Impressive–special	218.289***	42.123	[113.800;302.777]
Beautiful–special	−68.815	41.023	[−151.096;13.466]
Scale × PT			
Impressive–beautiful| 10 ms	−46.542	39.883	[−126.538;33.453]
Impressive–special| 10 ms	7.254	54.814	[−102.690;117.198]
Beautiful–special| 10 ms	53.796	43.462	[−33.378;140.970]
Impressive–beautiful| 50 ms	48.736***	64.235	[307.891;569.581]
Impressive–special| 50 ms	243.058**	79.443	[83.715;402.400]
Beautiful–special| 50 ms	−195.678**	59.747	[−60.698;111.111]
Impressive–beautiful| 100 ms	454.108***	70.088	[313.530;594.687]
Impressive–special| 100 ms	231.870**	72.823	[85.806;377.933]
Beautiful–special| 100 ms	−222.239**	71.020	[−364.687; −79.791]
Impressive–beautiful| 500 ms	449.406***	62.801	[323.443;575.368]
Impressive–special| 500 ms	366.472***	68.530	[229.019;503.925]
Beautiful–special| 500 ms	−82.934	69.855	[−57.177;223.044]
Impressive–beautiful| Unlimited	139.809	75.239	[−11.101;290.719]
Impressive–special| Unlimited	242.790**	73.040	[96.291;389.290]
Beautiful–special| Unlimited	102.981	78.565	[−54.601;260.564]

Note. *M* = mean difference; *SE* = standard error; 95% *CI* = 95% confidence interval.
*$p < .05$; **$p < .005$; ***$p \leq .0001$.
[a]*CI* Least significance difference corrected.

Table D2. Results of simple main effects analysis on response times for Experiment 2

Comparison	*M*	*SE*	95% *CI*[a]
PT			
20–30 ms	−9.918	47.801	[−105.795;85.960]
20–40 ms	−67.208	42.860	[−153.178;18.763]
20 ms–Unlimited	1370.249*	54.274	[−1479.110; −1261.389]
30–40 ms	−57.290	47.447	[−152.457;37.877]
30 ms–Unlimited	−1360.332*	58.106	[−1476.878; −1243.786]
40 ms–Unlimited	−1303.042*	55.297	[−1413.954; −1192.129]

Note. *M* = mean difference; *SE* = standard error; 95% *CI* = 95% confidence interval.
*$p \leq .0001$.
[a]*CI* Least significance difference corrected.

Appendix E: Potential effects of repeated exposure

Table E. Results of repeated-measures ANOVA on Fisher's *Z* corrected correlations between the scales per PT for Experiment 1

Variable	*df*[a]	*F*	*p*	η_p^2
PT	1.735, 90.201	15.831	≤.0001	.233
Block	1.861, 96.791	0.539	.573	.010
PT × Block	3.264, 169.729	1.532	.205	.029

Note. [a]Greenhouse–Geisser $\hat{\varepsilon}$ corrected degrees of freedom (*df*).